

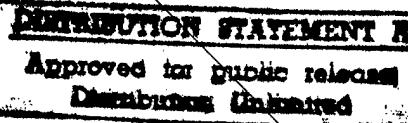


## CMM<sup>sm</sup> Version 1.1 Measurement Map

Robert E. Park

October 1996

19961202 077



Carnegie Mellon University does not discriminate and Carnegie Mellon University is required not to discriminate in admission, employment, or administration of its programs or activities on the basis of race, color, national origin, sex or handicap in violation of Title VI of the Civil Rights Act of 1964, Title IX of the Educational Amendments of 1972 and Section 504 of the Rehabilitation Act of 1973 or other federal, state, or local laws or executive orders.

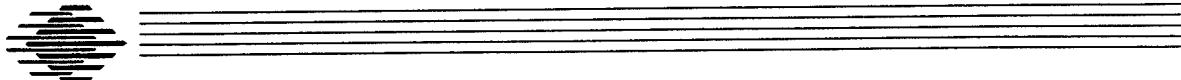
In addition, Carnegie Mellon University does not discriminate in admission, employment or administration of its programs on the basis of religion, creed, ancestry, belief, age, veteran status, sexual orientation or in violation of federal, state, or local laws or executive orders. However, in the judgment of the Carnegie Mellon Human Relations Commission, the Department of Defense policy of "Don't ask, don't tell, don't pursue," excludes openly gay, lesbian and bisexual students from receiving ROTC scholarships or serving in the military. Nevertheless, all ROTC classes at Carnegie Mellon University are available to all students.

Inquiries concerning application of these statements should be directed to the Provost, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213, telephone (412) 268-6684 or the Vice President for Enrollment, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213, telephone (412) 268-2056.

Obtain general information about Carnegie Mellon University by calling (412) 268-2000.

**Special Report**  
CMU/SEI-96-SR-003  
October 1996

## **CMM<sup>sm</sup> Version 1.1 Measurement Map**



**Robert E. Park**

Software Engineering Measurement and Analysis

Unlimited distribution subject to the copyright

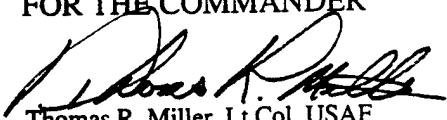
**Software Engineering Institute**  
Carnegie Mellon University  
Pittsburgh, PA 15213

This report was prepared for the

SEI Joint Program Office  
HQ ESC/AXS  
5 Eglin Street  
Hanscom AFB, MA 01731-2116

The ideas and findings in this report should not be construed as an official DoD position. It is published in the interest of scientific and technical information exchange.

FOR THE COMMANDER



Thomas R. Miller, Lt Col, USAF  
SEI Joint Program Office

This work is sponsored by the U.S. Department of Defense.

Copyright © 1996 by Carnegie Mellon University.

Permission to reproduce this document and to prepare derivative works from this document for internal use is granted, provided the copyright and "No Warranty" statements are included with all reproductions and derivative works.

Requests for permission to reproduce this document or to prepare derivative works of this document for external and commercial use should be addressed to the SEI Licensing Agent.

#### NO WARRANTY

THIS CARNEGIE MELLON UNIVERSITY AND SOFTWARE ENGINEERING INSTITUTE MATERIAL IS FURNISHED ON AN "AS-IS" BASIS. CARNEGIE MELLON UNIVERSITY MAKES NO WARRANTIES OF ANY KIND, EITHER EXPRESSED OR IMPLIED, AS TO ANY MATTER INCLUDING, BUT NOT LIMITED TO, WARRANTY OF FITNESS FOR PURPOSE OR MERCHANTABILITY, EXCLUSIVITY, OR RESULTS OBTAINED FROM USE OF THE MATERIAL. CARNEGIE MELLON UNIVERSITY DOES NOT MAKE ANY WARRANTY OF ANY KIND WITH RESPECT TO FREEDOM FROM PATENT, TRADEMARK, OR COPYRIGHT INFRINGEMENT.

This work was created in the performance of Federal Government Contract Number F19628-95-C-0003 with Carnegie Mellon University for the operation of the Software Engineering Institute, a federally funded research and development center. The Government of the United States has a royalty-free government-purpose license to use, duplicate, or disclose the work, in whole or in part and in any manner, and to have or permit others to do so, for government purposes pursuant to the copyright license under the clause at 52.227-7013.

This document is available through Research Access, Inc., 800 Vinial Street, Pittsburgh, PA 15212. Phone: 1-800-685-6510. FAX: (412) 321-2994. RAI also maintains a World Wide Web home page. The URL is <http://www.rai.com>

Copies of this document are available through the National Technical Information Service (NTIS). For information on ordering, please contact NTIS directly: National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161. Phone: (703) 487-4600.

This document is also available through the Defense Technical Information Center (DTIC). DTIC provides access to and transfer of scientific and technical information for DoD personnel, DoD contractors and potential contractors, and other U.S. Government agency personnel and their contractors. To obtain a copy, please contact DTIC directly: Defense Technical Information Center, Attn: FDRA, Cameron Station, Alexandria, VA 22304-6145. Phone: (703) 274-7633.

Use of any trademarks in this report is not intended in any way to infringe on the rights of the trademark holder.

## Table of Contents

<b>1</b>	<b>Overview</b>	<b>1</b>
	Genesis and Structure	1
	Prerequisites	2
	Objectives	2
	Current Applications	2
	Improving the CMM	2
 <b>2</b>	 <b>The Measurement Map</b>	 <b>5</b>
	Format and Notation	5
	The CMM's View of Software Measurement	6
	Part 1: The Software Process—Measures and Things to Be Measured	7
	Part 2: Key Process Areas and Activities	22
	Part 3: The Software Process Database	49
 <b>References</b>		 <b>53</b>



# CMM v1.1 Measurement Map

**Abstract:** This report identifies and tabulates all references to software measures and measurement activities that appear in Version 1.1 of the Capability Maturity Model<sup>sm</sup> for Software (CMM<sup>sm</sup>). Each reference is listed in a structured format, and the results are sorted into topic areas in a way that is designed to help organizations plan the evolution of their measurement activities across the key process areas of the CMM. Where the CMM's guidance is unclear or incomplete, opportunities for improving the CMM are noted and explained.

## 1 Overview

### Genesis and Structure

This report is the result of the author's attempt to identify all references to software measures and measurement activities that occur in Version 1.1 of the Capability Maturity Model for Software (CMM) [Paulk 93a, 93b, 95]. It presents a table that sorts the CMM's statements with respect to measurement into related topics and maps the sequencing of measurement activities across the levels of the CMM. The measurement map is presented in three parts, as follows:

Part 1—The Software Process: Measures and Things To Be Measured (Measures and activities associated with the software process itself)	Pages 7–21
Part 2—Key Process Areas and Activities (Measures and activities related to individual key process areas of the CMM)	Pages 22–48
Part 3—The Software Process Database (Statements that the CMM makes relative to data to be saved and activities associated with the software process database)	Pages 49–52

The first page of each part lists the topics within that part of the measurement map and shows the page numbers within the map where the topics can be found.

---

<sup>sm</sup> CMM and Capability Maturity Model are service marks of Carnegie Mellon University.

## **Prerequisites**

Users of this report and of the measurement map are presumed to have a basic familiarity with the CMM.

## **Objectives**

The measurement map of the CMM was prepared with the following objectives in mind:

1. Consolidate and organize the guidance that the CMM provides with respect to software measurement.
2. Provide a systematic listing of measures and measurement activities that can help organizations assess the coverage and effectiveness of their software measurement practices, as they relate to the goals and key process areas of the CMM.
3. Identify and summarize the evolutionary progression of measurement activities that the CMM envisions as organizations progress to higher levels of process maturity.
4. Help organizations introduce software measures and measurement activities in ways that support a smooth progression up the maturity ladder.
5. Help practitioners identify where measures and measurement practices can be used for multiple purposes, so that economies in measurement can be achieved.
6. Identify ways in which the CMM's treatment of software measurement can be improved as the CMM evolves toward Version 2.0.

## **Current Applications**

One major U.S. company with multiple sites and multiple lines of business is using the CMM measurement map in this report to provide a structure for assessing the measurement practices of its various software organizations. Extracts from the map are providing the baselines against which coverage and effectiveness of local measurement activities are being evaluated. The company's first objective is to understand where each operating organization stands with respect to installing and using measures that support their planned progressions to higher maturity levels. Its second objective is to identify opportunities for improving its measurement processes and practices.

## **Improving the CMM**

In pulling the summary table together, numerous opportunities for improving the correctness, completeness, clarity, and consistency of the CMM's treatment of measurement and

statistical methods became apparent. These opportunities have been noted and explained in the comments within the table. The potential areas for improvement include

- making terminology, requirements, and examples of software measures and measurement activities internally consistent
- eliminating impossible or unproductive requirements and examples
- eliminating redundancies
- coordinating measures and measurement activities among key process areas, so that economies in collecting, storing, analyzing, and reporting measurement results can be achieved
- identifying closely related measures and measurement activities, so that opportunities for commonality and sharing can be exploited
- improving the evolutionary path of measurement practices across CMM maturity levels, so that measurement activities that appear useful for Levels 2 and 3 do not turn out to be counterproductive at Levels 4 and 5
- correcting errors and misunderstandings in the CMM's references to statistical methods and in its discussions of the use of control charts and statistical process control for managing and improving software processes
- improving coverage (Some important aspects related to measurement and the use of measurement results were found missing. These are identified and explained.)
- improving the clarity and correctness of the presentation and discussion of measurement issues
- providing guidelines and advice for the quantitative and operational aspects of software process databases, so that the databases may more effectively serve the estimating, planning, and process improvement needs of software organizations

The measurement map, together with and the comments and recommendations it contains, is being used as an input to the development of Version 2.0 of the CMM.



## 2 The Measurement Map

### Format and Notation

Column One of the measurement map lists the actions, measures, indicators, and requirements for measurement that are mentioned in Version 1.1 of the CMM. Bold-faced type highlights specific measures and things to be measured.

Column two identifies the locations in the CMM where the references occur (sometimes there is more than one reference). The notation used is shown below. With this notation, entries such as "PP A7.5, PR Ab3" show that the item was mentioned in Activity 7.5 of the Software Project Planning KPA and in Ability 3 of the Peer Reviews KPA.

Symbol	Key Process Area (KPA)
<u>Level 2</u>	
RM	Requirements Management
PP	Software Project Planning
PTO	Software Project Tracking and Oversight
SM	Software Subcontract Management
SQA	Software Quality Assurance
SCM	Software Configuration Management
<u>Level 3</u>	
OPF	Organizational Process Focus
OPD	Organizational Process Definition
TP	Training Program
IM	Integrated Software Management
PE	Software Product Engineering
IG	Intergroup Coordination
PR	Peer Reviews
<u>Level 4</u>	
QPM	Quantitative Process Management
QM	Software Quality Management
<u>Level 5</u>	
DP	Defect Prevention
TCM	Technology Change Management
PCM	Process Change Management

Symbol	Section of the Key Process Area
G	Goals
C	Commitment to perform
Ab	Ability to perform
A	Activities performed
M	Measurement and analysis
V	Verifying implementation

Column 3 of the measurement map contains notes, observations, clarifications, and recommendations that represent the views of the author.

Columns 4–7 identify the categories into which the measures or activities fall. The notation used is as follows:

Symbol	Category
R	A required measure or action
I	Implied by a required measure or action
T	Classified by the CMM as a typical measure or action (i.e., alternatives are permitted)
E	Cited by the CMM as an example of a representative measure or action
X	Implied by an example measure or action

Users of the measurement map should keep in mind that the CMM contains no requirements. It is purely a descriptive model, not a prescriptive one. The author's use of the term "required" in this report should be interpreted in the sense that the measure or action is required if an organization is to be considered compliant with the CMM.

## The CMM's View of Software Measurement

The measurement map is presented on the pages that follow. It consists of three parts, as shown below. The topics in each part are listed on the first page of the part.

**Part 1: The Software Process—Measures and Things to Be Measured**

**Page 7**

**Part 2: Key Process Areas and Activities**

**Page 22**

**Part 3: The Software Process Database**

**Page 49**

# **CMM v1.1 Measurement Map**

## **Part 1**

### **The Software Process: Measures and Things to Be Measured**

<b>Topic</b>	<b>Page</b>
Size	8
Complexity	9
Reuse	10
Computer Resources	10
Support Facilities	11
Effort	11
Staffing	12
Schedule	13
Cost	16
Productivity	17
Risk	18
Testing	18
Scrap and Rework	18
Quality (organizational focus)	19
Quality (project focus)	19

## CMM v1.1 Measurement Map

Measures and things to be measured are shown in bold face.

**R** = Required   **I** = Implied   **T** = Typical   **E** = Example   **X** = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2					Level 3					Level 4					Level 5							
			P	R	P	S	S	O	O	C	C	F	P	T	I	P	I	Q	P	Q	D	C	C		
Size (actual) of generated code	PTO A5.2	Implies periodic measurement & reporting			R	P	T	S	S	Q	C	M	F	D	P	T	I	P	I	Q	P	D	C	C	
Size (actual) of fully tested code	PTO A5.2	Implies periodic measurement & reporting			R	P	T	S	S	Q	C	M	F	D	P	T	I	P	I	Q	P	D	C	C	
Size (actual) of delivered code	PTO A5.2	Implies periodic measurement & reporting			R	P	T	S	S	Q	C	M	F	D	P	T	I	P	I	Q	P	D	C	C	
Size (actual) for (major) software work products	OPD A5.1, IM A5.1, A5.3 PTO A5.1 PTO A5.1 PTO A5.3 IM A7.2 QPM A4.2	"Major" = ? Implies periodic measurement, reporting, and review Implies periodic measurement & reporting Implies periodic measurement & reporting			R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	
Size (actual) for changes to (major) software work products																									
Track the above measures.																									
Units (actual) of delivered documentation																									
Size (of the system) (actual)																									
Size (actual)																									
A group independent of the software engineering group																									
-reviews the procedures for estimating size (and changes to size) of software work products																									
-provides guidance in using historical data to establish credible estimates (An example of an independent group is a software estimating group.)	IM A6.1																								
-Individuals who prepare size estimates ensure the procedures and data they use are appropriate.	IM A6.1																								
-When the validity of a size estimate is questioned, a team of peers and experts reviews the estimate.	IM A6.1																								
-Apply contingency factors to the size estimates for each software element identified as a software risk.	IM A6.2																								
-Document the rationale for the contingency.	IM A6.2																								
-Assess and document the risks associated with eliminating the contingency.	IM A6.2																								
Complexity																									
Complexity (of the system)	IM A7.2																								
Geographic locations of the project's groups, organizations, and subcontractors																									
Host environment (for development)																									
Target environment																									
The developer's familiarity with the application																									
Availability of resources																									
Other special constraints																									

Measures and things to be measured are shown in bold face.

R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2		Level 3		Level 4		Level 5	
			P	R	S	O	O	P	Q	T
<b>Reuse</b>		Reuse measurement is closely coupled to size measurement. The CMM errs in deferring reuse measurement to Level 3. Reuse estimates and measures must be used at Level 2 for project planning and project tracking, so that size measures can be interpreted correctly.	R	P	S	O	O	P	Q	T
Identify off-the-shelf or reusable components.			M	P	T	C	C	D	P	P
Use this information to manage size and as a basis for reuse measures.			M	O	M	A	M	F	M	M
<b>Reuse measures</b>		Account for reuse of requirements, design, code, test plans, & test procedures. The effort to modify and incorporate reusable components is factored into the size estimates.	M	A	M	F	M	E	G	M
Degree of program modification	TCM Ab4	This doesn't make sense! You can have size=>size, effort=>effort, or size=>effort, but not effort=>size.	T	T	T					E
<b>Computer resources</b>										
Computer memory capacity (estimated)	PP A11.1	PP A11.1	E	E	E	E	E	E	E	R
Communication channel capacity (estimated)	PP A11.1	PP A11.1	E	E	E	E	E	E	E	R
Processor use (estimated)	PP A11.1	PP A11.1	E	E	E	E	E	E	E	R
Critical computer resource usage (estimated)	PP A7.7	PP A11.2	R	R	R	R	R	R	R	T
Use a documented procedure.	PP A11	PP A11.2	R	R	R	R	R	R	R	T
Relate estimates to size of work products, operational processing load, and communications traffic.	PTO A7.1	PTO A7.1	T	T	T	T	T	T	T	T
Estimate usage for each major software component.	IM A8.1	IM A8.1								
Base estimates on historical experience, simulations, prototyping, or analysis.	IM A8.1	IM A8.1								
Record the similarities and differences between the project and the historical data.	IM A8.1	IM A8.1								
Record the reasoning used to judge the credibility of the estimates.	IM A8.1	IM A8.1								
Document sources and rationales.	PP A11.3	PTO A7.2								
Document changes that affect software commitments.	PTO A7.1	PTO A7.2								
<b>Critical computer resource usage (projected)</b>	PTO A7.1	PTO A7.2								
Track and compare to plan.	PTO A7.1	PTO A7.2								
Document changes that affect software commitments.	PTO A7.1	PTO A7.2								
<b>Critical computer resource usages (actual)</b>										
Track and compare to plan.	PTO A7.1	PTO A7.2								
<b>Critical computer resources (available capacities) (actual)</b>	PTO A7.1	PTO A7.2								
Planned values can (and often do) differ from estimates.	IM A8.4	IM A8.4								
If estimating and measuring computer resources are so important to Level 2, it seems strange that the CMM defers planning for these issues until Level 3.	IM A8.4	IM A8.4								
<b>Critical computer resource capacities (planned)</b>	IM A8.4	IM A8.4								
<b>Critical computer resources (reserve capacities) (planned)</b>	IM A8.4	IM A8.4								

Measures and things to be measured are shown in bold face.

Page 10

R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2				Level 3			Level 4			Level 5		
			R	P	S	S	R	P	S	C	O	R	P	Q	T
<b>Support Facilities</b> <b>Capacity requirements (estimates) for support facilities</b> Base estimates on estimated sizes of software work products. Examples of support facilities include development computers & peripherals, test computers & peripherals, target computer environment software, and support software.	PP A14.1 PP A14.1 PP A14.1		R	R	E		R	D	P	M	E	G	R	M	M
<b>Effort</b> <b>Software effort (estimated) for the project</b>	PP A7.6, A10, PTO A6, IM A5.3 PP A10 PP A10.3 IM A7.1 PP A10.3 PP A10.2	For productivity data to be meaningful, there must be mechanisms for normalizing productivities across differing projects and situations. This implies the need for a rationale and structure for attributing cause and effect, so that results can be related to controllable or environmental parameters. Perhaps the CMM should address this. It is unlikely that effective estimating can ever be reduced to simple productivity numbers. The real issues here are cost model use and cost model calibration.	R	R	R	T	R	E	E	T	T	E	X	E	
<b>Effort</b> <b>Software effort (estimated) for preparing for peer reviews</b> <b>Effort (estimated) for participating in peer reviews</b>	PP A10.1 PP A10.4 PP A10.4 PTO A6.3 IM A7.1 IM A7.4 PP A10.3 OPD A5.1 IM A7.3 IM A6.3 IM A6.3 PR Ab3 PR Ab3	Relate estimates to estimates for size of work products or changes. Document and review assumptions. Document and review estimates. Adapt the models used to estimate effort to the project. Update the parameter values of the models used in estimating software effort whenever major changes are made to the software requirements. <b>Effort (estimated) over the software life cycle</b> <b>Effort (estimated) for software work products</b> <b>Effort allocated to individually managed tasks or stages</b> Factor effort into the size estimates. <b>Effort (estimated) for preparing for peer reviews</b> <b>Effort (estimated) for participating in peer reviews</b>	T	T	T	R	T	T	E	T	T	T	X	X	E
<b>Effort</b> <b>SQA effort (planned)</b> <b>SCM effort (planned)</b> <b>Effort (planned) for process assessment</b> <b>Effort (planned) for process development and improvement</b> <b>Effort (planned) to manage the project</b>	SQA M1 SCM M1 OPF M1 OPF M1 IM M1														

Measures and things to be measured are shown in bold face.

R = Required   I = Implied   T = Typical   E = Example   X = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, Indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2				Level 3				Level 4				Level 5			
			P M	S O	S O	P T	S Q	C P	T I	P I	P Q	D C	C M	G R	M E	G R	M P	M M
<b>Effort expended (for planning tasks)</b>	PP M1																	
<b>Software effort (actual) for the project</b>	PTO M1 PTO A6, A6.1, OPD A5.1 IM A5.1, A7 PTO A6.1	Implies that the work completed must also be measured and tracked. Implies periodic measurement & reporting.	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	
Track, over time, against work completed.																		
Compare to plan.																		
<b>SQA effort expended (actual)</b>	SQA M1																	
<b>SCM effort expended (actual)</b>	SCM M1																	
<b>Effort (expended) for process assessment</b>	OPF M1																	
<b>Effort (expended) for software products</b>	OPD A5.1																	
<b>Effort (actual) to manage the project</b>	IM M1																	
<b>Magnitude of replanning effort</b>	IM M1																	
<b>Effort to analyze each proposed change to a requirement</b>	PE M2																	
<b>Cumulative effort to analyze proposed changes to requirements</b>	IG M1																	
<b>Effort (actual) expended by the software engineering group to support other engineering groups</b>	IG M1																	
<b>Effort (actual) expended by other engineering groups to support the software engineering group</b>	PR A3 TCM Ab4 TCM Ab4																	
<b>Rework effort resulting from peer reviews</b>																		
<b>Effort to fix products and processes</b>																		
<b>Resource expenditures by project, process stage, tools &amp; methods used, program category, degree of program modification, etc.</b>																		
<b>Effort (estimated/revised) for remaining work</b>	IM A5.3, A7.4 IM A7.4																	
<b>Updated estimates use actual productivity data from the current project where appropriate.</b>																		
<b>Use a documented procedure to manage the project's software effort.</b>	IM A7																	
 <b>Staffing</b>																		
<b>Staffing (estimated)</b>	PP A10.3, PTO A6.3 PP A10.3																	
Base estimates on past experience.																		
Use similar projects when possible.																		
Document staffing estimates in the software development plan.																		
Use historical data where appropriate.																		
Adapt models used to plan staffing profiles to the project.																		
<b>Staffing distribution (estimated) over the software life cycle</b>	IM A7.1 PP A10.3																	
<b>Staffing (actual)</b>	PTO A6.3, IM A5.1 PTO A6.3 PTO A6.4																	
Compare to plan.																		
Document all staffing changes that affect commitments.																		

Measures and things to be measured are shown in bold face.

R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2				Level 3				Level 4				Level 5				
			P	S	S	O	O	C	P	P	T	I	P	P	Q	T	P	D	C
<b>Schedule (planned)</b>																			
Use a documented procedure to derive each project's schedule.																			
Relate schedule to estimates for sizes of work, products or changes.																			
Relate schedule to software effort and costs.																			
Base schedule on experience (use similar projects, if possible).																			
Identify milestones and reviews.																			
Document and review schedules.																			
Account for critical dependencies																			
- within the software engineering group																			
- between the software engineering group and other groups																			
- between critical paths.																			
<b>Completion dates (milestones) (planned)</b>																			
Completion criteria																			
Dates of reviews (planned)																			
Completion criteria																			
Time phasing of activities (planned)																			
Dates of imposed milestones (planned)																			
Critical dependency dates (planned)																			
Other constraints (planned)																			
Activity durations and times between milestones are appropriate to support accuracy																			
in measuring progress.																			
<b>Planned dates for project planning milestones</b>																			
<b>Schedule for work completed (planned)</b>																			
Completion dates (activities) (planned)																			
Completion dates (other commitments) (planned)																			
Schedule (completion dates) (planned)																			
- activities																			
- milestones																			
- commitments																			
Document these dates in the software development plan.																			
<b>Schedule revisions</b>																			
Document schedule revisions.																			
<b>Delivery dates (planned) for subcontracted products</b>																			
Dates (planned) for deliveries to the subcontractor																			
Schedule for the project's SQA group's activities																			
SQA milestone dates (planned)																			
SQA work scheduled (planned)																			
SCM milestone dates (planned)																			
SCM work scheduled (planned)																			

Measures and things to be measured are shown in bold face.

R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2			Level 3			Level 4			Level 5			
			P	S	S	O	O	P	T	I	P	Q	T	P	
<b>Schedule milestones (dates) for process development</b>	OPD M1	The CMM says development, but the context is definition.	R	P	T	S	Q	C	P	T	I	P	Q	D	C
<b>Schedule (dates?) for process maintenance</b>	OPD M1 IM A10.1		M	P	O	M	A	M	F	D	P	M	E	G	R
<b>The schedule for the QPM activities to be performed</b>	QPM A2.4														
<b>Schedule milestones for QPM activities (planned)</b>	QPM M1														
- milestones for establishing process measurements to be used on the project															
- milestones for determining how process data will be collected															
- milestones for collecting the project's process data															
<b>Schedule for software process development</b>	PCM A9.3														
<b>Schedule for software process improvement</b>	PCM A9.3														
<b>Schedule (estimated)</b>	QPM A4.2														
<b>Completion dates (actual) for project planning milestones</b>	PP M1														
<b>Schedule (actual)</b>	PTO A8.1, IM A5.1, PCM A9.3, QPM A4.2														
<b>Completion dates (activities) (actual)</b>	PTO A8.1														
<b>Completion dates (milestones) (actual)</b>	PTO A8.1														
<b>Completion dates (other commitments) (actual)</b>	PTO A8.1														
<b>Schedule (completion dates) (actual)</b>	PTO A8														
- activities															
- milestones															
- commitments															
Compare these dates to those documented in the software development plan.															
<b>Delivery dates (actual) for subcontracted products</b>															
<b>Dates (actual) for your deliveries to the subcontractor</b>															
<b>Milestone completion dates (completed)</b>	SM M1														
<b>SCQA work completed (actual)</b>	SOA M1														
<b>SCM milestone dates (completed)</b>	SCM M1														
<b>SCM work completed (actual)</b>	SCM M1														
<b>Task completion dates (actual) for software engineering (SE) support to other engineering groups</b>	IG M1														
<b>Milestone completion dates (actual) for SE support to other engineering groups</b>															
<b>Task completion dates (actual) for support by other engineering groups</b>	IG M1														
<b>Milestone completion dates (actual) for support by other engineering groups to the software engineering group</b>	IG M1														
<b>Milestone completion dates (actual) for support by other engineering groups to the software engineering group</b>	IG M1														

Measures and things to be measured are shown in bold face.

R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2					Level 3					Level 4					Level 5					
			P	S	S	O	O	R	P	T	S	Q	C	P	T	I	P	P	Q	T	P	D	C
<b>Schedule milestones for QPM activities (actual)</b>	QPM M1 QPM M1		R	P	T	S	Q	M	P	O	M	A	M	F	D	P	M	E	G	R	M	M	M
- dates when process measurements are established for use on the project	QPM M1																						
- dates when the procedures for collecting process data have been determined	QPM M1																						
- dates when the project's process data are collected	QPM M1 QPM M1																						
Compare the actual dates to those in the approved plan.																							
<b>Schedule (estimated)planned versus actual</b>	QPM A4.2	This statement is unclear. Does the slash imply "and" or "or" or a ratio? A better way to say it would be "Plot all three (estimated, planned, and actual) on the same chart."																					
<b>Schedule time (actual) by project, process stage, program category, program size, degree of program modification, etc.</b>	TCM Ab4																						
<b>Schedule performance</b>	PCM A9.3																						
<b>Expected cycle-time benefits from process improvement proposals</b>	PCM A5.3																						

Measures and things to be measured are shown in bold face.

Page 15

R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, Indicator, or requirement	References	Notes, Implied requirements, and points needing clarification	Level 2			Level 3			Level 4			Level 5					
			P	S	S	O	O	C	P	P	I	P	Q	T	P	D	C
Cost Costs (estimated) for the project	PP A7.6, OPD A5.1, IM A5.3 PP A10 PP A10.1 PP A10.2 PP A10.3 PP A10.3 IM A7.1 IM A7.1 IM A7.2 IM A7.4 PP A10.4 PP A10.4 PTO A6.2	Relate estimates to estimates for size of work products or changes. Include direct labor, overhead, travel, computer costs, etc. Use productivity data (historical or current). Base estimates on past experience. Use similar projects when possible. Use historical data where appropriate. Adapt models used to estimate cost to the project. Adjust the referenced cost data to incorporate project variables. Update the parameter values of the models used in estimating software costs whenever major changes are made to the software requirements. Document and review assumptions. Document and review estimates. Document in the software development plan.	R	R	T	E	E	T	T	T	T	T	T	T	T	T	T
Cost distribution (estimated) over the software life cycle	PP A10.3 OPD A5.1 IM A7.3 PE M2	Costs (estimated) for software work products Costs allocated to individually managed tasks or stages Cost (initial estimate) for implementing and testing each	E	T	E												
Incorporated product engineering change	QPM A4.2	Cost data (estimated/planned) used to control the project's defined software process	The slash does not appear to mean division. Whether it means "and" or "or" is not clear.														
Costs (planned) for managing each subcontract	SM M1 QPM M1 DP V1.6	Cost over time for QPM activities (planned) Projected cost of planned defect prevention activities															
Costs (actual) for the project	PTO A6, A6.1, OPD A5.1, IM A5.1, A7 PTO A6.1, A6.2 PTO A6.4 SM M1 OPD A5.1 OPD M1 PE M2	Track, over time, against work completed. Compare to plan. Document all cost changes that affect commitments. Costs (actual) for managing each subcontract Costs (actual) for software work products Costs for process definition activities Cost (actual) for implementing and testing each incorporated product engineering change	R	R	R	E	E	E	E	E	E	E	E	E	E	E	

Measures and things to be measured are shown in bold face.

Page 16

R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example

# CMM v1.1 Measurement Map

Issue	Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2					Level 3					Level 4					Level 5						
				P	R	S	T	S	O	O	P	T	I	P	I	P	Q	T	P	D	C	C	M	P	M
<b>Cost over time for QPM activities (actual)</b>	Compare actual costs to those in the plan.	QPM M1																							
<b>Cost (actual) for achieving software quality goals</b>	Cost for achieving quality goals	QM M1																							
<b>Cost of poor quality</b>	Cost of poor quality	QM M1																							
<b>Cost for identifying each defect</b>	Cost for identifying each defect	DP A5.2																							
<b>Cost for correcting each defect</b>	Cost for correcting each defect	DP A5.2, M1																							
<b>Estimated cost of not fixing each defect</b>	Estimated cost of not fixing each defect	DP A5.2																							
<b>Cost of holding causal analysis meetings</b>	Cost of holding causal analysis meetings	DP M1																							
<b>Cost of completed defect prevention activities</b>	Cost of completed defect prevention activities	DP V1.6																							
<b>Cost of software process development</b>	Cost of software process development	PCM A9.3																							
<b>Cost of software process improvement</b>	Cost of software process improvement	PCM A9.3																							
<b>Costs (estimated) for remaining work</b>	Costs (estimated) for remaining work	IM A7.4																							
<b>Use a documented procedure to manage the project's software costs, if appropriate.</b>	Use a documented procedure to manage the project's software costs, if appropriate.	IM A7																							
<b>Productivity</b>	<b>Productivity data</b>	PP A10.2, OPD A5.1, QPM A4.2, PCM A9.3	It would be helpful if the CMM issued a cautionary note or two about productivity numbers—most software productivities are unnormalized. Hence they cannot be compared and are often misleadingly misused.																						
<b>Productivity</b>	<b>- by project</b>	TCM Ab4, PCM A9.3																							
	<b>- by process stage</b>	TCM Ab4																							
	<b>- by tools and methods used</b>	TCM Ab4																							
	<b>- by program category</b>	PCM Ab4																							
	<b>- by degree of program modification</b>	PCM Ab4																							
	<b>Productivity goals</b>	PCM A5.1																							
	<b>- for the organization's software processes</b>	PCM M1																							
	<b>- for each project's software processes</b>	PCM M1																							
	<b>Productivity (actual)</b>	PCM M1																							
	<b>- for the organization's software processes</b>	PCM A9.3	Making productivity trends meaningful within individual projects is likely to be difficult.																						
	<b>- for each project's software processes</b>	PCM M1	Normalization mechanisms are needed.																						
	<b>Productivity trends for each project</b>	PCM A9.3	?? This seems like an excessive requirement.																						
	<b>Organizational productivity trends</b>	PCM A9.3	?? This seems like an excessive requirement.																						
	<b>Productivity of software process development</b>	PCM A9.3	?? This seems like an excessive requirement.																						
	<b>Productivity of software process improvement</b>	PCM A9.3	?? This seems like an excessive requirement.																						
	<b>Expected productivity benefits of process improvement proposals</b>	PCM A5.3	?? This seems like an excessive requirement.																						

Measures and things to be measured are shown in bold face.

R = Required I = Implied T = Typical E = Example X = Implied by Example

CMM v1.1 Measurement Map

Measures and things to be measured are shown in bold face.

**R = Required**   **I = Implied**   **T = Typical**   **E = Example**   **X = Implied by Example**

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2				Level 3				Level 4				Level 5								
			P	S	S	O	O	P	T	P	T	P	I	P	Q	T	P	R	P	T	C	D	C
<b>Quality (organizational focus)</b>			M	P	O	A	M	F	D	P	M	E	G	R	M	P	M	M	P	M	M	P	M
Measurements are made and used to determine the status of the software quality management activities.																							
<b>Cost of poor quality</b>	QM M1																						
<b>Cost for achieving quality goals</b>	QM M1																						
<b>Organizational quality trends</b>	PCM A9.3																						
<b>Quality goals for the organization's software processes</b>	PCM M1																						
<b>Quality (project focus)</b>																							
<b>Quality measurements</b>	OPD A5.1, QPM A4.2 PCM A9.3																						
<b>Number of defects in software requirements</b>	OPD A5.1, QPM A4.2 PCM A9.3																						
<b>Number of defects in software code</b>	OPD A5.1, QPM A4.2 PCM A9.3																						
<b>Quality of the software products</b>	OPD A5.1, QPM A4.2 PCM A9.3																						
<b>Number of defects in software products</b>	PE M1 PE M1																						
<b>Track cumulatively by life-cycle stage.</b>	PE M1, TCM Ab4 PE M1, TCM Ab4																						
<b>Types of defects in software products</b>	PE M2																						
<b>Length of time the problem has been open</b>																							
<b>Number of product defects related to each life-cycle stage</b>	QM A3.5, TCM Ab4 QM A1.2																						
<b>Post-delivery defects (predicted values)</b>	QM A1.2																						
<b>Post-delivery defects (target values)</b>	QM A1.2																						
<b>Post-delivery defects (measured values)</b>	QM A1.2																						
<b>Percent of predicted defects found by the end of the test cycle</b>	QM A3.5																						
<b>Product and process defect data that relates</b>																							
<b>Stage introduced</b>	TCM Ab4																						
<b>Stage removed</b>	TCM Ab4																						
<b>Type</b>	TCM Ab4																						
<b>Cause</b>	TCM Ab4, PCMA5.1																						
<b>Severity</b>	TCM Ab4																						
<b>Time to fix</b>	TCM Ab4																						
<b>Effort to fix</b>	TCM Ab4																						
<b>Data on activities to fix product and process defects</b>	TCM Ab4																						
<b>Defect ID</b>	TCM Ab4																						
<b>Product version where fix was implemented</b>	TCM Ab4																						
<b>Identification of defects introduced in implementing each fix</b>	TCM Ab4																						
<b>Density of defects</b>	TCM Ab4																						
<b>By project</b>	TCM Ab4																						
<b>By product type</b>	TCM Ab4																						
<b>For each product</b>	TCM Ab4																						
<b>For subproducts (e.g., modules)</b>	TCM Ab4																						

Measures and things to be measured are shown in bold face.

R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2			Level 3			Level 4			Level 5		
			P	S	S	O	O	P	T	T	P	Q	T	P
<b>Quality goals for each project's processes</b>	PCM A9.3 PCM M1	Examining quality trends within a project is likely to be difficult and less meaningful than examining them across projects. Perhaps the CMM should focus on project-to-project trends here. Alternatively, it should illustrate ways in which quality trends within projects might be meaningful and useful.	R	P	T	S	C	P	P	T	I	P	Q	D
Each program's defect history			M	P	O	M	A	F	D	P	M	E	R	C
Quality trends for each project			M	P	O	M	A	F	D	P	M	E	R	M
<b>Software reliability measures</b>														
<b>Severity of defects in software requirements</b>	OPD A5.1, QPM A4.2													
<b>Severity of defects in software code</b>	OPD A5.1, QPM A4.2													
<b>Severity of problem</b>	TCM Ab4													
<b>Severity of defects in software products</b>	OPD A5.1, QPM A4.2													
Track cumulatively by stage	PE M2, TCM Ab4													
	PE M1, TCM Ab4													
	PE M1, TCM Ab4													
<b>Quality goals for each life-cycle stage</b>	PCM A3.5, PCM A5.1													
<b>Quantitative goals for each identified quality characteristic</b>	QM A3, A3.3													
<b>Measurable values (required to be achieved) for each identified quality characteristic</b>	PCM A5.1													
<b>Measurable values (desired levels) for each identified quality characteristic</b>	QM A3.3													
<b>Quality measures (actual values) for each life-cycle stage</b>	QM A4.2													
<b>Software mean time between failures (MTBF) specified by requirements</b>	QM A3.3													
<b>Software MTBF (planned)</b>	QM A3.3													
<b>Software MTBF that must be achieved, as determined by analysis &amp; experiment</b>	QM A3.3													
<b>Cost (actual) for achieving software quality goals</b>	QM A4.5													

Measures and things to be measured are shown in bold face.

R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example

## CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2					Level 3			Level 4			Level 5								
			P	S	S	O	O	R	P	T	S	Q	C	P	I	P	Q	T	P	D	C	C
			R	P	T	S	Q	C	P	T	I	P	I	P	Q	R	M	F	D	P	M	M
The organization has a written policy for measuring and quantitatively controlling each project's defined software process.	QM C1																					
The organization has a documented procedure for developing and maintaining software quality plans for each project.	QM A1																					
The project follows the written organizational policy for managing software quality. Each project's software quality management activities support the organization's commitment to improve the quality of software products.	QM C1.1																					
Each project defines and collects the measurements used for quality management based on its defined software process.	QM C1.2																					
Each project defines quality goals for its software products.	QM C1.3																					
Each project monitors its progress towards its quality goals.	QM C1.3																					
Each project defines responsibilities for software quality management are defined and assigned.	QM C1.4																					
Projects establish criteria to enable its groups to determine their success in achieving the quality goals of their software products.	QM C1.4																					
Each project has a software quality plan.	QM A1																					
Each project's software quality plan is developed and maintained according to a documented procedure.	QM A1																					
Each project measures and understands the software quality needs of its organization, customer, and end users. Examples of ways to measure include surveys, focus groups, and product evaluations.	QM A1.1																					
Characteristics of product quality (how well it will perform, how well it can be developed and maintained) are identified.	QM A3.1																					
Measurements are used to quantify the characteristics of software product quality. Quality goals for software products are documented in each project's software quality plan.	QM A3.2																					
Quality goals are defined and documented for each software life-cycle stage. Each project's quantitative quality goals are monitored and revised throughout the software life cycle.	QM A3.4																					
Quality goals for the product and its life-cycle stages are revised as understanding of the product and of the organization's, customer's, and end user's needs evolve.	QM A3.5																					
Predicted values for the number of post-delivery defects are tracked and updated as the product matures.	QM A3.6																					
Product quality is measured, analyzed, and compared to goals.	QM A1.2																					
	QM A4 & A4.3	The CMM appends "...on an event-driven basis. This appears to have no semantic content.																				

Measures and things to be measured are shown in bold face.

Page 21

R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example

# CMM v1.1 Measurement Map

## Part 2

### Key Process Areas and Activities

Topic	Page
Requirements Management	23
Planning	24
Tracking	26
Subcontract Management	27
Software Quality Assurance	28
Software Configuration Management	28
Process Development and Improvement	29
Process Definition (organizational focus)	29
Process Definition (project focus)	29
Training	30
Integrated Software Management	30
Software Product Engineering	30
Intergroup Coordination	31
Peer Reviews	32
Process Management (project focus)	33
Process Management (organizational focus)	40
Process Management (enterprise focus)	42
Tools	42
Defect Prevention	43
Technology Change Management	45
Process Change Management	46

# CMM v1.1 Measurement Map

Issue	Action, measure, Indicator, or requirement	References	Notes, Implied requirements, and points needing clarification	Level 2				Level 3				Level 4				Level 5				
				R	P	S	S	R	P	T	S	C	P	T	I	P	Q	D	C	C
<b>Requirements Management</b>				R	P	S	S	R	P	T	S	C	P	T	I	P	Q	D	C	C
Measurements are made and used to determine the status of activities for managing the allocated requirements.	<b>Status of each allocated requirement</b>	RM M1, PE M2 RM M1, PE M2 TCM Ab4	Implies that a list of states must be defined. Implies that entry and exit dates for states must be recorded.	E	E	E	E	E	E	E	E	E	E	E	E	E	E	T	P	M
<b>Change activity for allocated requirements</b>		RM M1 RM M1 RM M1 RM M1 RM M1		E	E	E	E	E	E	E	E	E	E	E	E	E	E	D	C	C
<b>Cumulative number of changes to allocated requirements</b>	- number proposed - number open - number approved - number incorporated into system baseline	RM M1 RM M1 RM M1 RM M1		E	E	E	E	E	E	E	E	E	E	E	E	E	E	M	M	M
Measurements are made and used to determine the functionality of the software products.	<b>Number of allocated requirements, summarized by category</b>	PE M1 PE M1 PE M1 PE M1 PE M1 PE M1 PE M1 PE M1	In the sense of allocated requirements both by category and traced to software requirements and test cases.	E	E	E	E	E	E	E	E	E	E	E	E	E	E	R		
<b>Number of allocated requirements, summarized by category</b>	- number that are security requirements - number that are system configuration requirements - number that are performance requirements - number that are reliability requirements	PE M1 PE M1 PE M1 PE M1 PE M1 PE M1 PE M1 PE M1		E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	
<b>Number of allocated requirements traced to the software req'ts</b>	Number of allocated requirements traced to system test cases	PE M1 PE M1		E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
Other requirements measures and actions																				
Number of requirements for each major work product (estimated)	PP A9.1																			
Number of requirements for each major work product (actual)	PP A9.1, IM A6.3																			
Number of defects found in software requirements	OPD A5.1, QPM A4.2																			
Severity of defects found in software requirements	OPD A5.1, QPM A4.2																			
<b>Stability of the requirements</b>																				
Number of reused requirements	IM A7.2																			
Size (actual) for each incorporated change	IM A6.3																			
Effort to analyze proposed change to a requirement	PE M2																			
<b>Cumulative effort to analyze proposed changes to requirements</b>	PE M2																			
<b>Incorporated change</b>	PE M2																			
Cost (actual) for implementing and testing each incorporated change	PE M2																			
<b>Total number of requirements</b>	QPM A5.6																			
Compare the expansion ratio of software requirements (e.g., number of "shells") into the number of SLOC to upper and lower limits determined by analyzing historical data.	QPM A5.6																			

Measures and things to be measured are shown in bold face.

Page 23

R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example

The focus on upper and lower limits here seems a bit too strong. This is an estimating issue, not a process control situation. It would be better to look at the error distribution or scatter plot obtained when the historical data are fitted or otherwise mapped to the new situation.

To get usable ratios, models or categories should be used to account for the fact that things like programming languages, application classes, and system support environments can all affect the values observed.

# CMM v1.1 Measurement Map

Issue Action, measure, Indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2					Level 3					Level 4					Level 5				
			P R	P R	S P	S C	O P	O T	O I	P I	P Q	P D	C G	C R	C M	T P	T R	T E	T X			
<b>Planning</b> Measurements are made and used to determine the status of software planning activities.	PP M1	Implies the need for completion criteria. These should be stated explicitly.	R																			
<b>Planned dates for project planning milestones</b>	PP M1																					
<b>Completion dates for project planning milestones</b>	PP M1																					
<b>Work completed (for planning tasks)</b>	PP M1																					
<b>Effort expended (for planning tasks)</b>	PP M1																					
<b>Funds expended (for planning tasks)</b>	PP M1																					
<b>Planning data are recorded. These include</b>	PP A15 PP A15.1 PP A15.1 PTO A11.3	Recorded where? Since this is part of a Level-2 KPA, this appears to ask only that the data and estimates be recorded at the project level, in some project artifact. Archived where? What ensures that data 'archived' at Level 2 are available for (and get inserted into) the software process database at Level 3?  'Recorded' and 'archived' are not defined in the CMM's glossary. Perhaps they should be, so that notes stuffed in a desk drawer or stored in a box in the basement are not viewed as satisfying this requirement.	R																			
<b>- estimates</b>																						
<b>- information needed to reconstruct estimates</b>																						
<b>Planning data are archived.</b>																						
<b>Each project provides appropriate software planning data for storage.</b>	IM A5.3	Are storage and archiving the same things?	R																			
<b>Size of code (estimated)</b>	PTO A5.2 PTO A5.2 PTO A5.2 PTO A5.2 PTO A6 PTO A6.1, 6.3 PTO A6.3 PTO A6.3 PTO A6.3 PTO A6.1, 6.2 PTO A5.3 PTO A5.3 PTO A6.1		R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R				
<b>- generated</b>																						
<b>- fully tested</b>																						
<b>- delivered</b>		Document these estimates in the software development plan.																				
<b>Effort (estimated)</b>	PTO A6.1	Document these estimates in the software development plan.																				
<b>Staffing (estimated)</b>	PTO A6.3	Document these estimates in the software development plan.																				
<b>Costs (estimated)</b>	PTO A6.3	Document these estimates in the software development plan.																				
<b>Units of delivered documentation (estimated)</b>	PTO A6.1, 6.2	Document this estimate in the software development plan.																				
<b>Work completed (estimated) versus time and/or estimated effort and costs</b>	PTO A7 PTO A7.1 PTO A8 PTO A8.1 PTO A8.1 PTO A9.2	Critical computer resources for each major component	R																			
<b>Schedule (completion dates) (planned)</b>		Document these estimates in the software development plan.	R																			
<b>- activities</b>			R																			
<b>- milestones</b>			R																			
<b>- commitments</b>			R																			
<b>Release contents for successive builds (planned)</b>		Document these dates in the software development plan.	R																			

Measures and things to be measured are shown in bold face.

Page 24

R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example

## CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2			Level 3			Level 4			Level 5				
			P	S	S	O	O	P	T	P	T	I	P	Q	T	P
Replanning data are recorded. These include - estimates -information needed to reconstruct and verify estimates	PTO A11 PTO A11.1 PTO A11.3 IM A5.3	Where? How does archived differ from stored? "Appropriate" begs definition. What are the criteria for appropriate? Who determines them? If it's all arbitrary, then any data suffices.	R	R	R	R	R	R	R	R	R	R	R	R	R	R
Replanning data are archived.	OPD A6 OPD A6															
Each project provides appropriate software replanning data for storage.	IM M1 IM M1 IM M1															
Each project has a measurement plan.																
Project measurement plans are included in the organization's library of process-related documentation.																
Frequency of replanning Magnitude of replanning effort Causes of replanning effort																

Measures and things to be measured are shown in bold face.

R = Required   I = Implied   T = Typical   E = Example   X = Implied by Example

CMM v1.1 Measurement Map

Measures and things to be measured are shown in bold face.

**R = Required**   **I = Implied**   **T = Typical**   **E = Example**   **X = Implied by Example**

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2					Level 3					Level 4					Level 5								
			P	S	S	O	O	R	P	T	S	Q	C	P	P	T	I	P	I	P	Q	D	C	C	P	M
<b>Risk</b>																										
- number of unanticipated adverse impacts - magnitude of unanticipated adverse impacts	IM M1 IM M1																									
Actual measurement data are recorded. Actual measurement data are archived.	PTO A11 PTO A11.3	Recorded where? This should be spelled out. How does archived differ from recorded?						R																		
Measurements are made and used to determine the status of software tracking and oversight activities	PTO M1 PTO M1							R																		
<b>Effort expended in performing tracking and oversight</b>																										
<b>Other resources expended in performing tracking and oversight</b>																										
Change activity for the software development plan:	PTO M1, TCM Ab4																									
<b>Size estimate change activity</b>	PTO M1, TCM Ab4																									
<b>Cost estimate change activity</b>	PTO M1, TCM Ab4																									
<b>Critical computer resources estimate change activity</b>	PTO M1, TCM Ab4																									
<b>Schedule change activity</b>	PTO M1, TCM Ab4																									
<b>Number of defects in software products</b>	PE M1 PE M1																									
Track cumulatively by life-cycle stage.	PE M1, TCM Ab4																									
<b>Types of defects in software products</b>	PE M1, TCM Ab4																									
<b>Severity of defects in software products</b>	PE M1, TCM Ab4																									
Track cumulatively by stage.	PE M1, TCM Ab4																									
<b>Number of changes incorporated into the software baseline by category</b>	PE M2 PE M2																									
- number of interface changes	PE M2																									
- number of security changes	PE M2																									
- number of system configuration changes	PE M2																									
- number of performance changes	PE M2																									
- number of usability changes	PE M2																									
<b>Number of action items</b>	OPM A4.2 QPM A4.2																									
<b>Rate of closure of action items</b>	TCM Ab4 TCM Ab4																									
Change activity for software products and work processes:																										
<b>Amount of code produced</b>	TCM Ab4 TCM Ab4																									
<b>Amount of documentation produced</b>	TCM Ab4 TCM Ab4																									
<b>Subcontract Management</b>	SM M1	Implies separate measurements for each subcontractor.	R																							
Measurements are made and used to determine the status of activities for managing the software subcontract.																										

Measures and things to be measured are shown in bold face.

R = Required I = Implied T = Typical E = Example X = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2			Level 3			Level 4			Level 5							
			P	S	S	C	O	O	P	T	I	P	Q	T	P	D	C	C	
<b>Software Quality Assurance</b>			R	P	T	S	Q	C	P	T	I	P	Q	T	P	D	C	C	
<b>Resource requirements for the project's SQA group</b>	SQA A2.2		M	P	O	N	A	M	F	D	P	M	E	G	R	M	P	M	
- staff	SQA A2.2		R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	
- tools	SQA A2.2		R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	
- facilities	SQA A2.2		R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	
<b>Schedule for the project's SQA group's activities</b>	SQA A2.3		R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	
<b>Funding for the project's SQA group's activities</b>	SQA A2.3		R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	
Measurements are made and used to determine the cost and schedule status of the SQA activities.			E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	
<b>SCA milestones dates (planned)</b>	SQA M1		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<b>SCA milestone dates (completed)</b>	SQA M1		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<b>SCA work scheduled (planned)</b>	SQA M1		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<b>SCA work completed (actual)</b>	SQA M1		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<b>SCA effort expended (planned)</b>	SQA M1		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<b>SCA effort expended (actual)</b>	SQA M1		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<b>SCA funds expended (planned)</b>	SQA M1		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<b>SCA funds expended (actual)</b>	SQA M1		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Audits		The CMM does not explicitly address quality assurance audits or measures dealing with audits (counting them, tracking action items, etc.). Perhaps it should.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<b>Software Configuration Management</b>	SCM M1	Measurements are made and used to determine the status of the SCM activities.	R	E	E	X	E	E	E	E	E	E	E	E	E	E	E	E	E
<b>Number of change requests per unit time</b>	SCM M1	Processing completion dates must be recorded.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<b>The date each change request is processed</b>	SCM M1	Completion criteria must be defined.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<b>SCM milestone dates (planned)</b>	SCM M1		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<b>SCM work scheduled (planned)</b>	SCM M1		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<b>SCM work completed (actual)</b>	SCM M1		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<b>SCM effort expended (planned)</b>	SCM M1		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<b>SCM effort expended (actual)</b>	SCM M1		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<b>SCM funds expended (planned)</b>	SCM M1		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<b>SCM funds expended (actual)</b>	SCM M1		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Measures and things to be measured are shown in bold face.

Page 28

R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2				Level 3				Level 4				Level 5			
			P	S	S	O	C	P	T	I	P	P	Q	T	P	D	C	C
Process Development and Improvement	OPF M1																	
Measurements are made and used to determine the status of the organization's process development and improvement activities.	OPF M1																	
<b>Work (planned) for process assessment</b>	OPF M1																	
<b>Work (completed) for process assessment</b>	OPF M1																	
<b>Effort (planned) for process assessment</b>	OPF M1																	
<b>Effort (expended) for process assessment</b>	OPF M1																	
<b>Funds (planned) for process assessment</b>	OPF M1																	
<b>Funds (expended) for process assessment</b>	OPF M1																	
Results of process assessments	OPF M1																	
Recommendations from previous assessments	OPF M1																	
<b>Work (planned) for process development and improvement</b>	OPF M1																	
<b>Work (completed) for process development and improvement</b>	OPF M1																	
<b>Effort (planned) for process development and improvement</b>	OPF M1																	
<b>Effort (expended) for process development and improvement</b>	OPF M1																	
<b>Funds (planned) for process development and improvement</b>	OPF M1																	
<b>Funds (expended) for process development and improvement</b>	OPF M1																	
<i>Work (planned) for process definition activities</i>																		
<b>Schedule milestones (dates) for process development</b>	OPD M1																	
<b>Schedule milestones (dates) for process maintenance</b>	OPD M1																	
<b>Costs for process definition activities</b>	OPD M1																	
<i>Process Definition (organizational focus)</i>																		
Measurements are made and used to determine the status of the organization's process definition activities.	OPD M1																	
<b>Schedule milestones (dates) for process development</b>	OPD M1																	
<b>Schedule milestones (dates) for process maintenance</b>	OPD M1																	
<b>Costs for process definition activities</b>	OPD M1																	
<i>Process Definition (project focus)</i>																		
Each project's defined software process typically specifies that	IM A4.1																	
Provisions are made for gathering, analyzing, and reporting measurement data needed to manage the software project.	IM A4.2																	
Activities for estimating and tracking are tied to the key tasks and work products of the defined process.	IM A4.3																	
Readiness criteria are established, documented, and used for each key task.	IM A4.3																	
Completion criteria are established, documented, and used for each key task.	IM A4.3																	

Measures and things to be measured are shown in bold face.

R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example

CMM v1.1 Measurement Map

Issue	Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2		Level 3		Level 4		Level 5	
				R	P	S	S	O	O	T	P
Training	Measurements are made and used to determine the status of the training program activities.	TP M1	"Projected" seems to mean something different here than when used to describe size measures.	R	P	T	S	P	T	I	P
Attendance (projected) at each course	Attendance (actual) at each course	TP M1	"Projected" seems to mean something different here than when used to describe size measures.	R	P	T	S	P	T	I	P
Number of training waivers approved (over time)	Progress in providing training courses compared to project's plan	TP M1	TP M1	R	P	T	S	P	T	I	P
Progress in providing training courses compared to organization's plan	Progress in providing training courses compared to organization's plan	TP M1	TP M1	R	P	T	S	P	T	I	P
Quality of the training program	Course reviews from students	TP M2	TP M2	R	P	T	S	P	T	I	P
Results of post-training tests	Results of post-training tests	TP M2	TP M2	R	P	T	S	P	T	I	P
Feedback from software managers	Feedback from software managers	TP M2	TP M2	R	P	T	S	P	T	I	P
The individuals who develop a project's defined software process receive training in using the software process database.	The individuals who develop a project's defined software process receive training in using the software process database.	IM A12	IM A12	R	P	T	S	P	T	I	P
Software managers receive training in software estimating.	Software managers receive training in software estimating.	IM A13	IM A13	R	P	T	S	P	T	I	P
Software managers receive training in software tracking.	Software managers receive training in software tracking.	PE Ab2	PE Ab2	R	P	T	S	P	T	I	P
Technical staff receive training in measuring test coverage.	Technical staff receive training in measuring test coverage.	QPM Ab4	QPM Ab4	R	P	T	S	P	T	I	P
Individuals implementing or supporting quantitative process management receive the training needed to perform these activities.	Individuals implementing or supporting quantitative process management receive the training needed to perform these activities.	QPM Ab4	QPM Ab4	R	P	T	S	P	T	I	P
Examples of training include	Examples of training include	QPM Ab4	QPM Ab4	R	P	T	S	P	T	I	P
- modeling and analyzing the software process	- modeling and analyzing the software process	QPM Ab4	QPM Ab4	R	P	T	S	P	T	I	P
- selecting, collecting, and validating process measurement data	- selecting, collecting, and validating process measurement data	QPM Ab4	QPM Ab4	R	P	T	S	P	T	I	P
- applying basic quantitative methods and analysis techniques, such as estimation models, Pareto diagrams, and control charts	- applying basic quantitative methods and analysis techniques, such as estimation models, Pareto diagrams, and control charts	QPM Ab4	QPM Ab4	R	P	T	S	P	T	I	P
All members of the software engineering group and related groups receive orientation on the value and goals of quantitative process management.	All members of the software engineering group and related groups receive orientation on the value and goals of quantitative process management.	QPM Ab4	"Orientation" is not defined.	R	P	T	S	P	T	I	P
Individuals implementing and supporting software quality management receive training in measuring product and process quality.	Individuals implementing and supporting software quality management receive training in measuring product and process quality.	QPM Ab2	"Orientation" is not defined.	R	P	T	S	P	T	I	P
Integrated Software Management	Measurements are made and used to determine the effectiveness of the integrated software management activities.	IM M1	IM M1	R	P	T	S	P	T	I	P
Software Product Engineering	Measurements are made and used to determine the functionality of the software products.	PE M1	PE M1	R	P	T	S	P	T	I	P
Software Product Engineering	Measurements are made and used to determine the status of software product engineering activities.	PE M2	PE M2	R	P	T	S	P	T	I	P

Measures and things to be measured are shown in bold face.

**B = Required**      **I = Implied**      **T = Technical**      **E = Example**      **X = Implied by Example**

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2			Level 3			Level 4			Level 5			
			P	S	S	O	O	T	P	I	P	P	Q	T	P
<b>Intergroup Coordination</b>			R	P	T	S	Q	C	P	T	I	P	P	D	C
Measurements are made and used to determine the status of the intergroup coordination activities.			M	P	O	M	A	M	F	D	P	M	E	G	R
<b>Effort (actual) expended by the SE (software engineering) group to support other engineering groups</b>	IG M1														R
<b>Other resources expended by the SE group to support other engineering groups</b>	IG M1														E
<b>Effort (actual) expended by other engineering groups to support the software engineering group</b>	IG M1														E
<b>Other resources expended by other engineering groups to support the software engineering group</b>	IG M1														E
<b>Task completion dates (actual) for SE support to other engineering groups</b>	IG M1														E
<b>Milestone completion dates (actual) for SE support to other engineering groups</b>	IG M1														E
<b>Task completion dates (actual) for support by other engineering groups to the software engineering group</b>	IG M1														E
<b>Milestone completion dates (actual) for support by other engineering groups to the software engineering group</b>	IG M1														E

Measures and things to be measured are shown in bold face.

Page 31

R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example

## CMM v1.1 Measurement Map

Measures and things to be measured are shown in bold face.

**R = Required**   **I = Implied**   **T = Typical**   **E = Example**   **X = Implied by Example**

# CMM v1.1 Measurement Map

Issue Action, measure, Indicator, or requirement	References	Notes, Implied requirements, and points needing clarification	Level 2					Level 3					Level 4					Level 5												
			P	S	S	O	O	P	S	T	P	I	P	Q	T	M	P	O	M	A	M	F	D	P	M	E	G	R	M	M
<b>Process Management (project focus)</b>																														
The organization has a written policy for measuring the performance of each project's defined software process.	QPM C1	The CMM's statement here combines measuring with controlling. These are distinct actions that are probably best separated, especially if measuring for process improvement is also a goal.																												
The organization has a written policy for quantitatively controlling the performance of each project's defined software process.	QPM C1																													
Each project implements a documented plan to bring the project's defined software process under quantitative control.	QPM C1.1	This statement is imprecise and inadequately informative. The term "quantitative control" is open to so many possible interpretations that it is effectively meaningless. If statistical control is what is wanted, then the CMM should say so. If something else is intended, then the meaning should be made clear, and references that guide users toward achieving the goal should be provided. If statistical control is what is intended, then the CMM should probably point out that achieving statistical control means identifying and eliminating all assignable causes and demonstrating sustained performance within the natural limits of the process.																												
Each project's plan for quantitative process management is developed according to a documented procedure.	QPM A1.1																													
Each project's plan for QPM is based on	QPM A1.1																													
- the organization's strategic goals for product quality, productivity, and development time	QPM A1.1																													
- the organization's measurement program	QPM A1.1																													
- the organization's standard software process	QPM A1.1																													
- the project's goals for product quality, productivity, and development time	QPM A1.1																													
- the measured performance of other projects' defined software processes	QPM A1.1																													
- the description of the project's defined software process	QPM A1.1																													
Each project's QPM plan covers	QPM A2.1																													
- the goals and objectives of the QPM activities	QPM A2.1																													
- the software tasks and activities that will be measured and analyzed	QPM A2.2																													
- the instrumentation of the projects' defined software processes	QPM A2.3																													
- the QPM activities to be performed and the schedule for these activities	QPM A2.4																													
- (This includes not only project needs, but also current organizational needs and measurements that may be useful to future efforts.)	QPM A2.4																													
- the groups and individuals responsible for the QPM activities	QPM A2.5																													
- the staff, tools, and other resources required to perform the QPM activities	QPM A2.6																													
- the procedures to be followed in performing the QPM activities	QPM A2.7																													

Measures and things to be measured are shown in bold face.

R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, Indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2				Level 3				Level 4				Level 5			
			P	R	T	S	O	O	C	P	T	I	P	Q	D	C	C	P
Each project's QPM plan undergoes peer review.	QPM A1.2	"Peer" is not defined. What criteria should be used to determine "peer"? Without this clarification, the statement is meaningless. While peer review may be helpful, what is really needed here is review by someone (or a group) that is well-versed in statistical process control principles and methods. These may well be people from the hardware part of an organization. Unfortunately, it is all too easy for semi-knowledgeable people to have erroneous views of statistical principles associated with successful SPC. Important points will then be missed, and illogical and unworkable methods can easily get embedded in the plan.													T			
Each project's QPM plan is reviewed by the group responsible for the organization's software process activities (e.g., the SEPG). Each project's QPM plan is managed and controlled.	QPM A1.3 QPM A1.4	Apparently the SEPG review is in addition to the peer review. Is this so? "Managed and controlled" are defined in QPM A1.4.													T	T		
Sensitive data relating to performance of individuals are protected. Access to sensitive data relating to performance of individuals is controlled.	QPM C1.2	"Protected" is not defined. What constitutes adequate protection? "Controlled" (in this context) is not defined.													T			
The organization's process capability baseline is used in establishing each project's process performance goals. Managers and task leaders of the software engineering groups and related groups perform the project's quantitative process management activities. (Related groups include software engineering, SQA, SCM, and documentation support.) Adequate resources and funding are provided for quantitative process management activities.	QPM C2.2 QPM Ab2.1 QPM Ab2	Note that establishing such a baseline requires first that the process be brought under statistical control. Cost estimating should probably be included too. Adequate training is needed too, if success with statistical methods is desired.													R	E	R	
Each project's QPM activities are performed according to the project's QPM plan. The strategy for data collection is based on the project's defined software process. The analyses to be performed are based on the project's defined software process. The data collection and analyses strategies consider these attributes of the project's defined software process:	QPM A2 QPM A3 QPM A3	- the tasks, activities, and their relationships to each other - the software work products and their relationships to each other and to the project's defined software process - the process control points and data collection points													R	R	R	
The measurement data used to control each project's defined software process are collected according to a documented procedure. The measurement data used to control each project's defined software process support the organization's goals and objectives. The measurement data used to control each project's defined software process support the project's goals and objectives.	QPM A3.3 QPM A4 QPM A4.1	The implication is that the procedure is defined by the project. If this is the intent, perhaps it could be stated more clearly.													T	T		

Measures and things to be measured are shown in bold face.

Page 34

R = Required I = Implied T = Typical E = Example X = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, Indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2				Level 3				Level 4				Level 5				
			P	S	S	O	O	C	P	T	P	I	P	Q	T	P	D	C	C
			R	P	T	S	Q	C	P	T	I	P	Q	T	P	D	C	C	
			M	M	P	O	M	A	F	D	P	M	E	G	R	M	M	P	M
Each project documents precise definitions for the measurement data to be collected to control its defined software process.	QPM A4.2	This requirement seems to preempt QPM A5.8.																	
Each project defines and documents the intended use and analysis of each measurement used to control its defined software process.	QPM A4.2																		
Each project <u>predefines</u> the data analysis activities it will use to control its defined software process.	QPM A5.1																		
Each project's <u>predefined</u> description of data analysis activities covers																			
- input data required	QPM A5.1																		
- data manipulations performed	QPM A5.1																		
- information to be derived	QPM A5.1																		
- decision criteria to be used in (a) performing each analysis and (b) deciding what actions to take	QPM A5.1																		
Each project's predefined data analysis techniques include																			
- Pareto diagrams	QPM A5.1																		
- control charts	QPM A5.1																		
- trend diagrams	QPM A5.1																		
- scatter diagrams	QPM A5.1																		
Each project defines and documents the process control points at which its process control data will be collected.	QPM A4.2																		
Each project's process control measurements are chosen from the entire life cycle (including post-development stages).	QPM A4.3																		
The measurements used to control the project's defined software process appropriately characterize the process.	QPM A5.3	The CMM appends "they represent." This seems redundant.																	
The measurements cover the properties of the key software process activities.	QPM A4.4	"Major" is not defined.																	
The measurements cover the properties of the major software work products.	QPM A4.4	The CMM is not clear here. What are "controlled measurements"? What is a "natural result"?																	
The measurements to be controlled are a natural result of the software activities where possible.	QPM A4.6																		
The measurements are selected to support predefined analysis activities.	QPM A4.7	Validity of a measure is a different issue from that of correctness of the data. The CMM needs to be clearer here as to which it is asking for. Perhaps it should ask for both.																	
Measurements that are research oriented should be explicitly identified as such. The validity of the measurement data is independently assessed.	QPM A4.8	Perhaps the CMM should point out that validity of data (or measurement definitions) can only be judged in the context of intended use. Furthermore, if predictive validity is desired, this can only be verified with empirical evidence that the predictions work. Also " <u>independently assessed</u> " should be <u>defined</u> .																	

Measures and things to be measured are shown in bold face.

R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2					Level 3					Level 4					Level 5				
			P	S	S	O	O	P	T	T	P	I	P	Q	Q	T	P	D	C	C	M	P
Each project establishes a process performance baseline.	QPM A5.5	Process performance baseline is defined in the CMM's glossary. Should perhaps a distinction be made between a baseline based on needs (requirements) and a baseline based on extrapolations from demonstrated process performance. There is great danger when the two are confused.																			T	
When new software projects are substantially different from past projects, new process performance baselines are established for those projects as part of tailoring the organization's standard software process.	QPM A7.6	"Radical" may be too strong a word here. The issue is whether "Change" is not a good word here. The issue is whether the new project differs significantly in size from projects for which the organization's standard software process was designed. This is different from change in size since the start of the project.																			E	
Examples of substantial differences include	QPM A7.6 QPM A7.6 QPM A7.6	Excellent! But to avoid confusing the innocent, it should be pointed out that process capability cannot be established until the process is brought under statistical control (i.e., is operating stably).																			E	
Changes to the organization's standard software process are tracked and analyzed to assess their effects on the process capability baseline.	QPM A7.7	This is statistically erroneous. Expected values are never "specified." The data determine SAMPLE means and variances, which are often used to estimate the true means and variances. Perhaps the CMM means to say "target values." But SW process measures will seldom have stationary process means. Instead, we will usually be dealing with trajectories, such as cumulative effort, cost, work completed, problems reported, or problems fixed. Mean and expected value are concepts that seem more applicable to end-of-project data. But then they are not very useful for control purposes in the classical sense. Perhaps a better analogy when trajectories are being tracked is that of navigation (flight planning) and course correction.																			T	
Specify the expected values for the mean and variance of each measurement.	QPM A5.4	Be very careful here. Limits defined arbitrarily lead to overcontrolling and to destabilized processes. It would be wise to distinguish between the "voice of the customer" and the "voice of the process." If intelligent and effective actions are to be taken on the basis of these limits. See [Wheeler 92] and [Wheeler 95].																			T	
Each project defines acceptable limits for the measurements it uses to control its defined software process.	QPM A5.5																					

Measures and things to be measured are shown in bold face.

Page 36

R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2					Level 3					Level 4					Level 5							
			P	S	S	O	O	P	S	S	C	P	T	I	P	I	P	Q	T	P	D	C	C	M	P
An example of establishing acceptable limits is to calculate the historical deviation from the mean performance of the process.	QPM A5.5	This is confused and confusing. The preceding statement implies that limits for controlling project parameters such as size, effort, schedule, cost, and defects are what are wanted. These usually involve profiles over time (i.e., trajectories). What is needed are prediction intervals for these profiles, set according to some criteria that permits rare events to be identified. The profiles can be estimated only with a model that accounts for differences among projects. Except in the simplest of situations, calculating "the historical deviation from the mean performance of the process" will be both impossible and useless. Also, this kind of wide ranging variation is NOT what one should use to construct control limits [Wheeler 92].																							
Each project compares the actual values of its measurements to the expected values of the means and variances.	QPM A5.6	Projects will never know what the "expected" values are (in the probabilistic sense). The best they will ever have is the organization's estimates for these values. But even this presumes either that the project follows exactly the same process and that the product has exactly the same characteristics (size, reuse, language, application, etc.) as all others in the set used to develop the estimates, or that competent cost models are competently used to account for these differences. Today's cost models ATTEMPT (but don't necessarily succeed) to estimate expected "means," but few (if any) address variances in any realistic way. It would be more reasonable to require use of a model that estimates expected values and variances based on extrapolations from past projects. What is really needed is not estimates at completion, but estimates of the trajectories one expects to see over time. Perhaps the real issues the CMM should address here are																							
Projects adjust their processes to bring performance in line with the defined acceptable limits.	QPM A5.7	(a) comparison of actual values to planned values, and (b) comparison of the plan to historical experience. Limits that are too narrow cause overcontrolling, instability, and degradations in performance. The advice the CMM gives here should be accompanied by guidance that makes this clear. Also, adjustment alone is unlikely to help. It is almost always more effective to focus on identifying assignable causes and removing them, then work on process improvement.																							

Measures and things to be measured are shown in bold face.

R = Required   I = Implied   T = Typical   E = Example   X = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2					Level 3					Level 4					Level 5							
			P	S	S	O	O	P	T	S	Q	C	P	T	I	P	Q	D	C	C	P	M	M	M	
When the project's defined software process is controlled quantitatively, baselines are established for	QPM A5.8	From the context, the intent appears to be, 'To control its defined SW process quantitatively, each project should establish (statistically derived?) baselines for...' Since 'definition' is singular here, this appears to say that each process is to establish a baseline for its definition process. The context, though, suggests that each project is to establish baseline definitions for the measures it uses to control its SW process. But that requirement is already stated in QPM A4.2. Is QPM A5.8 redundant here?	M	P	O	M	A	F	D	P	M	E	G	R	M	M	M	M	P	M	M	M	M	T	
- the definition of measurements	QPM A5.8	The intent here is not clear. In what sense are baselines established for actual measurement data? How does establishing baselines for acceptable limits differ from simply establishing acceptable limits? Perhaps the CMM should point out that there are statistically valid ways for doing this (i.e., Shewhart's control charts). This may be important, since in practice invalid limits seem rampant.	T	T	T																				
- the actual measurement data	QPM A5.8	QPM A5.9	QPM A5.9	QPM A4.9	QPM A5	QPM A5.2	Are there any activities that are not "process" activities?																		
- the acceptable limits for the measurements																									
Manage and control the process performance baseline for each software project.																									
- The data collected to control each project's defined software process is stored in the organization's software process database, if appropriate.																									
Each project's defined software process is analyzed and brought under control according to a documented procedure.																									
Identify, collect, and analyze measurement data on process activities throughout the project's defined software process.																									
- Prepare and distribute reports that document the results of each software project's activities.																									
The results of data analysis (of the project's QPM activities) are reviewed with those affected by the data before they are reported to anyone else.	QPM A6.1	This is not always the smart thing to do. In some instances it is best to leave control charts in the hands of the people who operate and manage the process. Otherwise they become a "big brother is watching you" club that is used to beat people around the shoulders.	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	
Software managers, task leaders, and senior managers receive regular reports (of the project's QPM activities) appropriate to their needs.	QPM A6.2	For this to be a testable requirement, each organization or project should establish definitions for "appropriate" and "regular."	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	
The project manager, senior managers, software managers, and software task leaders receive specialized reports (of the project's QPM activities) on request.	QPM A6.4	For this to be a testable requirement, each organization or project should establish definitions for "appropriate" and "regular."	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	
The software quality assurance group receives regular reports (of the project's QPM activities) appropriate to its needs.	QPM A6.3	For this to be a testable requirement, each organization or project should establish definitions for "appropriate" and "regular."	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	

Measures and things to be measured are shown in bold face.

## CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2					Level 3			Level 4			Level 5		
			P	S	S	O	O	T	P	Q	P	Q	D	C	C	P
Measurements are made and used to determine the status of the activities for quantitative process management.	QPM M1	The context makes it appear that this applies to the project's QPM activities rather than to those of the organization. Should there not also be an organizational focus?	R	P	T	S	C	F	P	I	P	I	T	P	T	P
<b>Cost for QPM activities (over time) (planned)</b> <b>Cost for QPM activities (over time) (actual)</b> <b>Schedule milestones for QPM activities (planned)</b> - milestones for establishing process measurements <b>to be used on the project</b> - milestones for determining how process data will be collected <b>milestones for collecting the project's process data</b> <b>Schedule milestones for QPM activities (actual)</b> Each software project's activities for quantitative process mgmt are reviewed with the project manager on both a periodic and event-driven basis.	QPM M1 QPM M1															

Measures and things to be measured are shown in bold face.

Page 39

R = Required   I = Implied   T = Typical   E = Example   X = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, Implied requirements, and points needing clarification	Level 2					Level 3					Level 4					Level 5							
			R	P	S	S	O	R	P	T	S	C	P	P	I	P	Q	T	P	D	C	C	M	P	M
<b>Process Management (organizational focus)</b>																									
An organization-wide measurement program exists.	QPM Ab2.2	It's not at all clear that an organization-wide "program" is a prerequisite for successful process management. What's needed is organization-wide use of measurement practices that guide and motivate process management toward productive directions and that enable decisions to be based on factual information. A "program" is only one way to get there, and maybe not the best way at that. Perhaps organization-wide measurement "practices" would be better?																							
The organization-wide measurement program includes	QPM Ab2.2 QPM Ab2.2 QPM Ab2.2 QPM Ab2.2	- definition of organization-wide measurements - collection of organization-wide measurements - analysis of organization-wide measurements - quantitative measurement goals for the organization																							
A written policy for analyzing the process capability of the organization's standard software process exists.	QPM C2																								
A process capability baseline for the organization's standard software process is established and maintained.	QPM A7	This may not be easy. Establishing a process's capability requires that the process be brought under statistical control (shown to be stable). What variables does the CMM perceive should be measured to demonstrate its concept of stability? Without some elaboration here, this may be an impossible requirement. Excellent! But is this intended to apply to software subprocesses, or just to the overall software process? The meaning of "documented" is unclear here. For example, what constitutes acceptable documentation? The customary way to document process capability is to use control charts and performance histograms, sometimes supplemented by capability ratios. If this is what the CMM means, it should say so. If not, it should make its intent clear.																							
Measurements of process performance are analyzed to establish and maintain a process capability baseline.	QPM C2.1																								
The process capability baseline for the organization's standard software process is documented.	QPM A7.3																								
A documented procedure is used to establish and maintain the process capability baseline.	QPM A7																								
The process capability baseline for the organization's standard software process is managed and controlled.	QPM A7.5																								
The process capability baseline includes standard definitions and expected ranges for the measurements used.	QPM C2.1	This may be neither realistic nor practical. Perhaps the CMM should instead require standardized reporting and recording of definitions used for measurements. Note that "expected ranges" presuppose data about the future that are not yet in evidence. Assurances that a process will continue to operate in the same fashion and in the same environment in the future as in the past are the responsibility of the project or process manager, not of any statistical methods that might be used for baselining. The distinctions between analytic and enumerative studies are important here.																							

Measures and things to be measured are shown in bold face.

Page 40

R = Required I = Implied T = Typical E = Example X = Implied by Example

CMM v1.1 Measurement Map

Issue	Action, measure, indicator, or requirement	Notes, implied requirements, and points needing clarification	References	Notes, implied requirements, and points needing clarification	References	Notes, implied requirements, and points needing clarification	References	Notes, implied requirements, and points needing clarification	References	Notes, implied requirements, and points needing clarification	References	Notes, implied requirements, and points needing clarification	References	Notes, implied requirements, and points needing clarification	References	Notes, implied requirements, and points needing clarification	References	Notes, implied requirements, and points needing clarification	References
The process performance baseline for each project's defined software process is incorporated (as appropriate) into the process capability baseline for the organization's standard software process.	QPM A7.2	The purpose is to update the organization's baseline. Actual performance data should be used, not the project's "process performance baseline" established at the start of the project. The CMM uses the term "process performance baseline" in both an anterior and a posterior sense. This introduces confusion. (Compare QPM A5.5, 5.8, and 7.2).		The purpose is to update the organization's baseline. Actual performance data should be used, not the project's "process performance baseline" established at the start of the project. The CMM uses the term "process performance baseline" in both an anterior and a posterior sense. This introduces confusion. (Compare QPM A5.5, 5.8, and 7.2).		This may be an impossible requirement. When a project's actual software process differs from the organization's standard process (and it invariably will), there may be no completely valid way to aggregate the measured values with those of other projects. At best, it will require the use of models to normalize the data.		"And" seems to convey the intent better (i.e., why not do both?)		The examples that follow are misplaced. They have nothing to do with QPM A7—establishing and maintaining a baseline according to a documented procedure.		Is this example misplaced? It seems to deal with project issues, not organizational issues.		This example is misplaced. It deals with project issues, not organizational issues.		Does "group" imply at least two individuals? If so, why not say so? Alternatively, if one person might suffice in a small organization, say so.		"Adequate" is undefined. Without criteria for "adequate," this requirement has no semantic content.	
Process capability trends for the organization's standard software process are examined to predict likely problems or (and?) opportunities for improvements. Examples of using capability trends include		- predicting software defects and comparing predictions to actuals	QPM A7.4	- predicting the distribution and characteristics of defects remaining based on data from peer reviews and/or testing	QPM A7.4	- predicting the distribution and characteristics of defects remaining based on data from peer reviews and/or testing	QPM Ab1.1	- A group exists to coordinate the quantitative process management activities for the organization. This group is either part of the group responsible for the organization's software process activities (e.g., the software engineering process group), or its activities are closely coordinated with that group. Adequate resources and funding are provided for quantitative process management activities.	QPM Ab1	Support exists for collecting, recording, and analyzing data for selected process and product measurements. ("Product" data refers to product measurements used for analyzing the software process.)	QPM Ab2	Individuals implementing or supporting quantitative process management receive the training needed to perform these activities.	QPM Ab4	Examples of training include	QPM Ab4	QPM Ab4	QPM Ab4	QPM Ab4	QPM V1
		- modeling and analyzing the software process		- selecting, collecting, and validating process measurement data		- applying basic quantitative methods and analysis techniques, such as estimation models, Pareto diagrams, and control charts		- All members of the software engineering group and related groups receive orientation on the value and goals of quantitative process management.		- The activities for quantitative process mgmt are reviewed periodically with senior mgmt.					E	E	E	R	

Measures and things to be measured are shown in bold face.

**R = Required**   **I = Implied**   **T = Typical**   **E = Example**   **X = Implemented by Example**

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2					Level 3					Level 4					Level 5					
			P	S	S	O	O	P	P	T	I	P	I	P	Q	T	P	D	C	C	M	P	M
<b>Process Management (enterprise focus)</b>		The CMM does not address the use of software measurements for enterprise management. For example: How much software do we have? How much in each language? How many programmers? Designers? Systems engineers? What is our annual investment in CASE and other software tools? What are our trends related to these measures? Etc. Mature organizations address these questions—but at what level? And which KPAs should they be tied to?																					
<b>Tools</b>			<b>PP Ab3.2</b> PP Ab6.2					<b>R</b>															
				<b>QPM Ab2.3</b> QPM Ab2.3 QPM Ab2.3 QPM Ab2.3 QPM Ab2.3 QPM Ab2.3										<b>R</b>									
					<b>QM Ab1.2</b> QM Ab1.2 QM Ab1.2 QM Ab1.2 QM Ab1.2 QM Ab1.2										<b>R</b>								
						<b>PCM A4.1</b>																<b>R</b>	

Measures and things to be measured are shown in bold face.

Page 42

R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2					Level 3					Level 4					Level 5									
			P	S	S	O	O	R	P	T	S	Q	C	P	T	I	P	Q	T	P	C	C	D	C	M	P	M
<b>Defect Prevention</b>																											
Action proposals identified in causal analysis meetings are documented.	DP A5.1																										
<b>Originator</b>	DP A5.1																										
<b>Description of the defect</b>	DP A5.1																										
<b>Description of the defect cause</b>	DP A5.1																										
<b>Defect cause category</b>	DP A5.1																										
<b>Stage when the defect was Injected</b>	DP A5.1																										
<b>Stage when the defect was Identified</b>	DP A5.1																										
<b>Description of the action proposal</b>	DP A5.1																										
<b>Action proposal category</b>	DP A4.9																										
<b>Status</b>																											
<b>Action items resulting from action proposals are documented.</b>	DP A5.2																										
<b>Person responsible for implementing the action item</b>	DP A5.2																										
<b>A description of the areas affected</b>	DP A5.2																										
<b>The individuals who are to be kept informed</b>	DP A5.2																										
<b>The next date its status will be reviewed</b>	DP A5.2																										
<b>The rationale for key decisions</b>	DP A5.2																										
<b>A description of the implementation actions</b>	DP A5.2																										
<b>The time for identifying the defect</b>	DP A5.2																										
<b>The time for correcting the defect</b>	DP A5.2																										
<b>The cost for identifying the defect</b>	DP A5.2																										
<b>The cost for correcting the defect</b>	DP A5.2, M1																										
<b>The estimated cost of not fixing the defect</b>	DP A5.2																										
<b>Status</b>	DP A4.9																										

Measures and things to be measured are shown in bold face.

R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2				Level 3				Level 4				Level 5					
			P	S	S	O	O	C	P	P	T	I	P	P	Q	T	P	D	C	C
Number of action items proposed	DP V1.4 DP V1.4 DP V1.4 DP M1		R	P	T	S	Q	C	P	P	T	I	P	P	Q	T	P	D	C	C
Number of action items open																				R
Number of action items closed																				R
Profiles of the numbers of action items proposed, open, and closed																				R
Number of defects																				E
Number of defects injected in each stage (cumulatively for each project)	DP M1																			E
Number of defects injected in each stage over releases of similar products	DP M1																			E
<b>Summary of major defect categories</b>																				R
Frequency distribution of defects in major defect categories																				R
Summary of action categories, for actions related to defects																				R
Frequency distribution of major action categories related to defects																				R
Summary status of action proposals																				R
Summary status of action items																				R
A summary of the effectiveness and savings attributable to defect prevention activities																				R
Cost of holding causal analysis meetings																				R
Projected cost of planned defect prevention activities																				R
Defect prevention data are tracked across the teams coordinating defect prevention activities.																				R
Members of the software engineering group and other software-related groups receive feedback on the status and results of the organization's and project's defect prevention activities on a periodic basis.																				R
Compare time and cost for identifying and correcting defects with estimated cost of not correcting the defects.																				R
DP M1																				E

Measures and things to be measured are shown in bold face.

Page 44

R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2			Level 3			Level 4			Level 5					
			P	S	S	O	O	T	P	I	P	Q	T	P	D	C	C
<b>Technology Change Management</b>			R	P	T	S	C	P	T	I	P	Q	T	P	D	C	C
Experienced staff members with expertise in software measurement are available to help evaluate, plan, and support initiatives for technology change management.			M	P	O	M	A	F	D	P	M	E	G	R	M	P	M
Support exists for collecting and analyzing data needed to evaluate technology changes:																	
- Support for recording selected product and process data automatically	TCM Ab2.1																
- Support for data analysis		TCM Ab3															
- Support for displaying selected data			TCM Ab3.1														
- Results of data analysis are presented in formats that appropriately convey the information content, e.g., graphical displays			TCM Ab3.2														
<b>Data on software processes and work products that support selecting and evaluating technology changes</b>			TCM Ab3.3														
The group responsible for technology change management receive training in			TCM Ab3.4														
- the analytical and support facilities available to the organization			TCM Ab4														
- principles of statistical quality control			TCM Ab5														
			TCM Ab5														
Measurements are made and used to determine the status of the organization's activities for technology change management.				TCM M1													
<b>Number of technology changes</b>				TCM M1													
<b>Types of technology changes</b>				TCM M1													
<b>Sizes of technology changes</b>				TCM M1													
<b>Goals of technology changes</b>				TCM M1													
<b>Effects of technology changes, compared to the goals</b>				TCM M1													

Measures and things to be measured are shown in bold face.

R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, Indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2			Level 3			Level 4			Level 5		
			P R M	S T P O M	S Q C P A	O P T I M	P I P E D	Q D G R	T C M	P C M	T P C C	Q D C C	T P M M	
<b>Process Change Management</b>														
The organization has quantitative, measurable goals for software process improvement.	PCM C1.1													T
The organization tracks performance against process improvement goals.	PCM C1.1 PCM C1.3 PCM A2.7 PCM A8.2													T
Tools are made available to support statistical analysis of process improvement.														E
Changes to the organization's standard software process are tracked.														R
The strategy for collecting data to measure and track the change in process performance when transferring a software process improvement into normal practice is documented, reviewed, and agreed to by individuals responsible for implementing the processes affected by the change.														T
Support tools are instrumented, as appropriate, to record the desired performance data automatically.	PCM A8.2	Presumably, "instrumented" means "used." The CMM could be clearer here.												R
The organization's software process improvement plan covers the resources needed to implement the plan.	PCM A4.1 PCM A4.1 PCM A4.1													R
<b>Staff</b>														R
<b>Tools</b>														R
<b>Each proposal</b>														
<b>Expected benefits of each software process improvement proposal</b>	PCM A5.3 PCM A5.4													T
<b>Priority of software process improvement proposals selected for implementation</b>	PCM A9.1													T
<b>Initiation (date?)</b>														I
<b>Status of each software process improvement proposal</b>														
<b>Defined goals for implementing each process improvement</b>	PCM A5.7 PCM A9.1 PCM M1 PCM M1 PCM A5.8													T
<b>The actual effect of implementing each process improvement</b>														R
<b>Response time for each software process improvement proposal</b>														E
<b>Aggregate process improvement activities</b>														E
<b>Measurable short-term goals for process improvement</b>	PCM A4.3 PCM A4.3 PCM A5.1													R
<b>Measurable long-term goals for process improvement</b>	PCM A2.6 PCM A2.6 PCM A3.1													R
<b>Measured effectiveness of activities within the software process</b>	PCM A2.6 PCM A2.6 PCM A3.1													R
<b>Accomplishments of process improvement activities</b>	PCM A2.6, A10.3 PCM A10.3 PCM A10.3													T
<b>Participation in process improvement activities</b>														R
<b>Customer satisfaction indicators</b>														R
<b>Status of process improvement activities</b>														R
<b>Number of proposals submitted</b>														R
<b>Number of proposals open</b>														R
<b>Number of proposals completed</b>														R

Measures and things to be measured are shown in bold face.

Page 46

R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example

CMM v1.1 Measurement Map

Measures and things to be measured are shown in bold face.

$R = \text{Required}$     $I = \text{Implied}$     $T = \text{Typical}$     $E = \text{Example}$     $X = \text{Implied by Example}$

CMM v1.1 Measurement Map

Measures and things to be measured are shown in bold face.

**R = Required**   **I = Implied**   **T = Typical**   **E = Example**   **X = Implied by Example**

# **CMM v1.1 Measurement Map**

## **Part 3**

### **The Software Process Database**

<b>Topic</b>	<b>Page</b>
Data Storage & Use	50

CMM v1.1 Measurement Map

Measures and things to be measured are shown in **bold face**.

R = Required      I = Implied      T = Typical      E = Example      X = Implied by Example

# CMM v1.1 Measurement Map

Issue Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2				Level 3				Level 4				Level 5			
			P R M	S P O M	S Q C A	O P F	T I P D	P Q F	T P M M	C C R	T P M M	T P M M	C C R	T P M M	T P M M	T P M M		
The software process database contains																		
Product measures collected from projects	OPD C1.4																	
Lessons learned	OPD C1.4																	
Size estimates	OPD A5.1, IM A5.3																	
Effort estimates	OPD A5.1, IM A5.3																	
Cost estimates	OPD A5.1, IM A5.3																	
Revised estimates	IM A5.3																	
Size data (actual)	OPD A5.1, IM A5.3																	
Size of software work products	IM A5.1																	
Effort data (actual)	OPD A5.1, IM A5.1																	
Cost data (actual)	OPD A5.1, IM A5.1																	
Productivity data	OPD A5.1, PCM A9.3																	
Organizational productivity trends	PCM A9.3																	
Quality measurements	OPD A5.1, PCM A9.3																	
Organizational quality trends	PCM A9.3																	
Peer review coverage	OPD A5.1																	
Peer review efficiency	OPD A5.1																	
Test coverage	OPD A5.1																	
Test efficiency	OPD A5.1																	
Software reliability measures	OPD A5.1																	
Number of defects found in the software requirements	OPD A5.1																	
Severity of defects found in the software requirements	OPD A5.1																	
Number of defects found in the software code	OPD A5.1																	
Severity of defects found in the software code	OPD A5.1																	
Defect histories for each program	PCM A9.3																	
Schedule	IM A5.1																	
Schedule performance	PCM A9.3																	
Staffing	IM A5.1																	
Technical activities	IM A5.1																	
Task descriptions	IM A5.3																	
Assumptions	IM A5.3																	

Measures and things to be measured are shown in bold face.

R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example

# CMM v1.1 Measurement Map

Issue	Action, measure, indicator, or requirement	References	Notes, implied requirements, and points needing clarification	Level 2			Level 3			Level 4			Level 5					
				P	S	S	O	O	P	T	S	Q	C	P	Q	T	P	
				R	P	T	S	O	C	F	P	T	I	P	Q	D	C	C
				M	P	O	M	A	M	F	D	P	M	E	R	M	P	M
<b>Parameter values used to derive estimates for size, effort, cost, schedule, and use of critical computer resources</b>	IM A5.2	IM A7.4 IM A7.4 IM A5.3	Associated information needed to reconstruct estimates, assess reasonableness, and derive estimates for new work															
<b>Updated parameter values</b>	IM A5.2	IM A5.2	Similarities and differences to other projects															
	IM A5.2	IM A5.2	Rationales for similarities and differences between parameter values															
	IM A5.2	IM A5.2	The reasoning used to judge the credibility of the project's estimates															
	QPM A7.1	QPM A7.1	Each project's software process data, as summarized in its process performance baseline															
<b>Cost of software process development</b>	PCM A9.3	PCM A9.3	Cost of software process development															
<b>Cost of software process improvement</b>	PCM A9.3	PCM A9.3	Cost of software process improvement															
<b>Schedule for software process development</b>	PCM A9.3	PCM A9.3	Schedule for software process development															
<b>Schedule for software process improvement</b>	PCM A9.3	PCM A9.3	Schedule for software process improvement															
<b>Productivity of software process development</b>	PCM A9.3	PCM A9.3	Productivity of software process development															
<b>Productivity of software process improvement</b>	PCM A9.3	PCM A9.3	Productivity of software process improvement															
			?? This seems like an excessive requirement.															
			?? This seems like an excessive requirement.															

Measures and things to be measured are shown in bold face.

Page 52

R = Required    I = Implied    T = Typical    E = Example    X = Implied by Example

## References

[Fenton 91] Fenton, Norman E. *Software Metrics: A Rigorous Approach*. London: Chapman & Hall, 1991.

[Park 95] Park, Robert E. *Checklists and Criteria for Evaluating the Cost and Schedule Estimating Capabilities of Software Organizations* (CMU/SEI-95-SR-05, ADA 293 299). Pittsburgh, Pa.: Software Engineering Institute, Carnegie Mellon University, January 1995.

[Paultk 93a] Paultk, Mark C. et al. *Capability Maturity Model for Software, Version 1.1* (CMU/SEI-93-TR-24, ADA 263 403). Pittsburgh, Pa.: Software Engineering Institute, Carnegie Mellon University, February 1993.

[Paultk 93b] Paultk, Mark C. et al. *Key Practices of the Capability Maturity Model, Version 1.1* (CMU/SEI-93-TR-25, ADA 263 432). Pittsburgh, Pa.: Software Engineering Institute, Carnegie Mellon University, February 1993.

[Paultk 95] Paultk, Mark C.; Weber, Charles V.; Curtis, Bill; Chrassis, Mary Beth; et al. *The Capability Maturity Model: Guidelines for Improving the Software Process*. Reading, Ma: Addison-Wesley, 1995.

[Wheeler 92] Wheeler, Donald J. & Chambers, David S. *Understanding Statistical Process Control*. Knoxville, Tenn.: SPC Press, 1992.

[Wheeler 95] Wheeler, Donald J. *Advanced Topics in Statistical Process Control*. Knoxville, Tenn.: SPC Press, 1995.

## REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified		1b. RESTRICTIVE MARKINGS None					
2a. SECURITY CLASSIFICATION AUTHORITY N/A		3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for Public Release Distribution Unlimited					
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A							
4. PERFORMING ORGANIZATION REPORT NUMBER(S) CMU/SEI-96-SR-003		5. MONITORING ORGANIZATION REPORT NUMBER(S)					
6a. NAME OF PERFORMING ORGANIZATION Software Engineering Institute	6b. OFFICE SYMBOL (if applicable) SEI	7a. NAME OF MONITORING ORGANIZATION SEI Joint Program Office					
6c. ADDRESS (city, state, and zip code) Carnegie Mellon University Pittsburgh PA 15213		7b. ADDRESS (city, state, and zip code) HQ ESC/AXS 5 Eglin Street Hanscom AFB, MA 01731-2116					
8a. NAME OF FUNDING/ SPONSORING ORGANIZATION SEI Joint Program Office	8b. OFFICE SYMBOL (if applicable) ESC/AXS	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER F19628-95-C-0003					
8c. ADDRESS (city, state, and zip code) Carnegie Mellon University Pittsburgh PA 15213		10. SOURCE OF FUNDING NOS. <table style="width: 100%; border-collapse: collapse;"><tr><td style="width: 25%;">PROGRAM ELEMENT NO 63756E</td><td style="width: 25%;">PROJECT NO. N/A</td><td style="width: 25%;">TASK NO N/A</td><td style="width: 25%;">WORK UNIT NO. N/A</td></tr></table>		PROGRAM ELEMENT NO 63756E	PROJECT NO. N/A	TASK NO N/A	WORK UNIT NO. N/A
PROGRAM ELEMENT NO 63756E	PROJECT NO. N/A	TASK NO N/A	WORK UNIT NO. N/A				
11. TITLE (Include Security Classification) CMM Version 1.1 Measurement Map							
12. PERSONAL AUTHOR(S) Robert E. Park							
13a. TYPE OF REPORT Final	13b. TIME COVERED FROM                    TO	14. DATE OF REPORT (year, month, day) October 1996	15. PAGE COUNT 53				
16. SUPPLEMENTARY NOTATION							
17. COSATI CODES		18. SUBJECT TERMS (continue on reverse if necessary and identify by block number) Capability Maturity Model for Software (CMM), key process areas, measures, measurement					
FIELD	GROUP						
19. ABSTRACT (continue on reverse if necessary and identify by block number)							
<p>This report identifies and tabulates all references to software measures and measurement activities that appear in Version 1.1 of the Capability Maturity Model<sup>sm</sup> for Software (CMM<sup>sm</sup>). Each reference is listed in a structured format, and the results are sorted into topic areas in a way that is designed to help organizations plan the evolution of their measurement activities across the key process areas of the CMM. Where the CMM's guidance is unclear or incomplete, opportunities for improving the CMM are noted and explained.</p>							
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT UNCLASSIFIED/UNLIMITED <input checked="" type="checkbox"/> SAME AS RPT <input type="checkbox"/> DTIC USERS <input checked="" type="checkbox"/>		21. ABSTRACT SECURITY CLASSIFICATION Unclassified, Unlimited Distribution					
22a. NAME OF RESPONSIBLE INDIVIDUAL Thomas R. Miller, Lt Col, USAF		22b. TELEPHONE NUMBER (incl. area code) (412) 268-7631	22c. OFFICE SYMBOL ESC/AXS (SEI)				

ABSTRACT — continued from page one  
block 19